TO THE

READER.

THE following Tables I Received from Sir Samuel Morland, amongst the rest of his Mathematical Papers, all of which Kind he was pleased to bestow on me not long before his Death. As for these which I now Publish, he told me particu-

larly, that they contained the Myſtery of that Art and nimble Diſpatch, which he was Maſter of, in the Making and Managing of (more eſpecially) ſuch Mechanical Engines as relate to the Water; in the Improvement of which ſort he was ſo much happier than the reſt of Mankind. He thought that it might be an acceptable and uſeful piece of Service to the World, to range

these Materials in good Order; and where there should be occasion, to add so much light as might make them easily Intelligible to a Common Reader.

How I should do this, he gave me large Directions from his own Mouth, and I have punctually observed them, in the Compleating of this Piece; so that here are plain and easy Rules and Directions delivered in a perspicuous manner, that guide the

Practitioner into the Conciſeſt way of Calculation in theſe Matters; and almoſt infallibly ſecure him from Miſtakes and Errors, which are ſo vexatious and expenſive. And I think it is not neceſſary to give any larger Account of this Treatiſe. What other of his Papers may hereafter be made Publick, muſt be left to further Enquiry and Conſideration.

Joſeph Morland.

THE FIRST TABLE.

A Table of Squire Roots of all Numbers from 1 to 100.

Squ. Number.	Squa. Roots.	Difference
1	1.00	
		0.41
2	1.41	
		0.32
3	1.73	
		0.27
4	2.00	
		0.24
5	2.24	
		0.21
6	2.45	
		0.20
7	2.65	
		0.18
8	2.83	

Squa Number	Squa. Roots	Difference
8	2.83	
		0.17
9	3.00	
		0.16
10	3.16	
		0.16
11	3.32	
		0.14
12	3.46	
		0.15
13	3.61	
		0.13
14	3.74	
		0.13
15	3.87	

Squa. Number	Squa. Roots	difference.
15	3. 87	
16	4. 00	0. 13
17	4. 12	0. 12
18	4. 24	0. 12
19	4. 36	0. 12
20	4. 47	0. 11
21	4. 58	0. 11
22	4. 69	0. 11
23	4. 80	0. 11
24	4. 90	0. 10
25	5. 00	0. 10
26	5. 10	0. 10
27	5. 20	0. 10
28	5. 29	0. 09
29	5. 39	0. 10
30	5. 48	0. 09
31	5. 57	0. 09
32	5. 66	0. 09
33	5. 74	0. 08
34	5. 83	0. 09

Squa. Number	Squa. Roots	Difference
34	5. 83	
35	5. 92	0. 09
36	6. 00	0. 08
37	6. 08	0. 08
38	6. 16	0. 08
39	6. 24	0. 08
40	6. 32	0. 08
41	6. 40	0. 08
42	6. 48	0. 08
43	6. 56	0. 08
44	6. 63	0. 07
45	6. 71	0. 08
46	6. 78	0. 07
47	6. 86	0. 08
48	6. 93	0. 07
49	7. 00	0. 07
50	7. 07	0. 07
51	7. 14	0. 07
52	7. 21	0. 07
53	7. 28	0. 07

Squa. Number	Squa. Roots	Difference
53	7. 28	
		0. 07
54	7. 35	
		0. 07
55	7. 42	
		0. 06
56	7. 48	
		0. 07
57	7. 55	
		0. 07
58	7. 62	
		0. 06
59	7. 68	
		0. 07
60	7. 75	
		0. 06
61	7. 81	
		0. 06
62	7. 87	
		0. 07
63	7. 94	
		0. 06
64	8. 00	
		0. 06
65	8. 06	
		0. 06
66	8. 12	
		0. 07
67	8. 19	
		0. 06
68	8. 25	
		0. 06
69	8. 31	
		0. 06
70	8. 37	
		0. 06
71	8. 43	
		0. 06
72	8. 49	

Squa. Number.	Squa. Roots	Difference
72	8. 49	
		0. 05
73	8. 54	
		0. 06
74	8. 60	
		0. 06
75	8. 66	
		0. 06
76	8. 72	
		0. 05
77	8. 77	
		0. 06
78	8. 83	
		0. 06
79	8. 87	
		0. 05
80	8. 94	
		0. 06
81	9. 00	
		0. 06
82	9. 06	
		0. 05
83	9. 11	
		0. 06
84	9. 17	
		0. 05
85	9. 22	
		0. 05
86	9. 27	
		0. 06
87	9. 33	
		0. 05
88	9. 38	
		0. 05
89	9. 43	
		0. 06
90	9. 49	
		0. 05
91	9. 54	

Squa. Number	Squa. Roots	Difference
91	9. 54	
		0. 05
92	9. 59	
		0. 05
93	9. 64	
		0. 06
94	9. 70	
		0. 05
95	9. 75	
		0. 05
96	9. 80	
		0. 05
97	9. 85	
		0. 05
98	9. 90	

Squa. Number	Squa. Roots	Difference
98	9. 90	
		0. 05
99	9. 95	
		0. 05
100	10. 00	

The

The Use of the foregoing TABLE.

To find the Square Root of any given Number as far as Three Figures.

DIstinguish the given Number by Points, as is usual in the Extracting of Square Roots, and observe how many Figures belong to the first Point, which will be either one or two: If only one, then seek that Figure in the foregoing Table of Square Roots, in the first Column from one to nine inclusive, and write out the Root stand-

ſtanding directly over-againſt it in the ſecond Column; and take alſo the next lower difference out of the third Column, which you Multiply by the two next Figures of your given Number, and from the Product cut off two Figures, and add the remainder to the Root firſt written out. The Sum is the deſired Root. But if there be two Figures belonging to the firſt Point, then ſeek them in the firſt Column from 10 to 99 incluſive, and proceed as before.

Example. Extract the Square Root out of 276438. the Number diſtinguiſhed by the Points ſtandeth thus; 276438. and the Figures belonging to the firſt Point are 27. which being look'd in the firſt Column, you find over againſt it in the ſecond Column 520. and in the third Column

lumn the next lower difference 10, which Multiplied by 64 (the two next following Figures in the given Number) the Product is 640. and cutting off two Figures, the remainder is 6. to be added to 520. and the desired Root is 526.

THE

THE SECOND

TABLE.

A TABLE *of Cube Roots, from* 1 *to* 10, *and then continued for every Tenth Number from* 10 *to* 100.

Number	Cube Roots	Difference	Number	Cube Roots	Difference
1	1. 00	0. 26	4	1. 59	0. 12
2	1. 26	0. 18	5	1. 71	0. 11
3	1. 44	0. 15	6	1. 82	0. 09
4	1. 59		7	1. 91	

Number	Cube Roots	Difference
7	1. 91	
		0. 09
8	2. 00	
		0. 08
9	2. 08	
		0. 07
10	2. 15	
		0. 56
20	2. 71	
		0. 40
30	3. 11	
		0. 31
40	3. 42	
		0. 26
50	3. 68	
		0. 23
60	3. 91	
		0. 21
70	4. 12	
		0. 19
80	4. 31	
		0. 17
90	4. 48	
		0. 16
100	4. 64	
		0. 15
110	4. 79	
		0. 14
120	4. 93	
		0. 14
130	5. 07	
		0. 12
140	5. 19	
		0. 12
150	5. 31	
		0. 12
160	5. 43	
		0. 11
170	5. 54	

Number	Cube Roots	Difference
170	5. 54	
		0. 11
180	5. 65	
		0. 10
190	5. 75	
		0. 10
200	5. 85	
		0. 09
210	5. 94	
		0. 09
220	6. 04	
		0. 09
230	6. 13	
		0. 08
240	6. 21	
		0. 09
250	6. 30	
		0. 08
260	6. 38	
		0. 08
270	6. 46	
		0. 08
280	6. 54	
		0. 08
290	6. 62	
		0. 07
300	6. 69	
		0. 07
310	6. 77	
		0. 07
320	6. 84	
		0. 07
330	6. 91	
		0. 07
340	6. 98	
		0. 07
350	7. 05	
		0. 06
360	7. 11	

Number	Cube Roots	Difference
360	7. 11	
370	7. 18	0. 07
380	7. 24	0. 06
390	7. 31	0. 07
400	7. 37	0. 06
410	7. 43	0. 06
420	7. 49	0. 06
430	7. 55	0. 06
440	7. 61	0. 06
450	7. 66	0. 05
460	7. 72	0. 06
470	7. 77	0. 05
480	7. 83	0. 06
490	7. 88	0. 05
500	7. 94	0. 06
510	7. 99	0. 05
520	8. 04	0. 05
530	8. 09	0. 05
540	8. 14	0. 05
550	8. 19	0. 05

Number	Cubick Roots	Difference
550	8. 19	
560	8. 24	0. 05
570	8. 29	0. 05
580	8. 34	0. 05
590	8. 39	0. 05
600	8. 43	0. 04
610	8. 48	0. 05
620	8. 53	0. 05
630	8. 57	0. 04
640	8. 62	0. 05
650	8. 66	0. 04
660	8. 71	0. 05
670	8. 75	0. 04
680	8. 79	0. 04
690	8. 84	0. 05
700	8. 89	0. 05
710	8. 92	0. 03
720	8. 96	0. 04
730	9. 00	0. 04
740	9. 04	0. 04

Number	Cubick Roots	Difference
740	9. 04	
750	9. 09	0. 05
760	9. 13	0. 04
770	9. 17	0. 04
780	9. 21	0. 04
790	9. 24	0. 03
800	9. 28	0. 04
810	9. 33	0. 05
820	9. 36	0. 03
830	9. 40	0. 04
840	9. 44	0. 04
850	9. 47	0. 03
860	9. 51	0. 04
870	9. 55	0. 04
880	9. 58	0. 03
890	9. 62	0. 04

Number	Cubick Roots	Difference
890	9. 62	
900	9. 65	0. 03
910	9. 69	0. 04
920	9. 73	0. 04
930	9. 76	0. 03
940	9. 80	0. 04
950	9. 83	0. 03
960	9. 86	0. 03
970	9. 90	0. 04
980	9. 93	0. 03
990	9. 97	0. 04
1000	10. 00	0. 03

THE

The Use of the Second TABLE.

To find the Cubick Root of any given Number as far as Three Figures.

DIstinguish the given Number by Points, as is usual in Extracting Cubick Roots. Then to the first Point towards the left Hand, there will belong either one Figure, or two, or three Figures. If it be one, then look the same in the Table of Cubick Roots, from 1 to 9 inclusive, if there be two Figures belonging to the first Point, then look the first of them from 10 to 90 inclusive,

cluſive, if there be three, look the two firſt from 100 to 990 incluſive, and write out the Root ſtanding directly over-againſt it in the Second Column, and the next lower Difference out of the third Column, which you Multiply by the two next Figures of your given Number, and from the Product cut off two Figures, and add the remainder to the Root firſt written out: The Sum is the deſired Root.

Example. Extract the Cubick Root out of 34167942. The Number diſtinguiſhed by Points ſtandeth thus: 34167942. and the Figures belonging to the firſt Point are 34, whereof the firſt, *viz.* 3. is to be look'd between 10 and 90. incluſive; and you find 30. and the Root of this in the Second Column 311. to be written out, and

and the next leſſer Difference in the third Column is 31. which Multiplied by 41. (the two next following Figures in the given Number) the Product is 1271. and cutting off two Figures, the remainder is 12 or 13. (becauſe the Figures cut off, *viz.* 71. are more than the half of 100.) which added to 311. (the Root firſt written out) the Sum is 324. the deſired Cubick Root.

THE

THE THIRD TABLE.

A TABLE *of Cube-Root-Inches, from a Pint to a Gallon, from a Gallon to a Barrel, from a Barrel to a Tun, from One Tun to Seventy, and from thence by Decimal Steps to* 10000.

Pints	Cube Root Inch.	Pints	Cube Root Inch.
1	3. 27	5	5. 60
2	4. 16	6	5. 95
3	4. 72	7	6. 27
4	5. 20		

Gallons

Gallons	Cube Root Inch.
1	6. 55
2	8. 26
3	9. 45
4	10. 40
5	11. 21
6	11. 91
7	12. 54
8	13. 11
1) 9	13. 63
10	14. 12
11	14. 58
12	15. 01
13	15. 41
14	15. 80
15	16. 17
16	16. 52
17	16. 86
2) 18	17. 18
19	17. 49
20	17. 80

Firkins

Firkins	Cube Root Inch.
21	18. 09
22	18. 37
23	18. 64
24	18. 91
25	19. 17
26	19. 42
3) 27	19. 67
28	19. 91
29	20. 14
30	20. 37
31	20. 60
32	20. 81
33	21. 03
34	21. 24
35	21. 45
36	21. 65

Cube-Root-Inches of Barrels and Tuns.

Barrels	Cube Root Inch.	Barrels	Cube Root Inch.
Tuns 1	21.65	13	50.91
2	27.28	14	52.18
3	31.22	15	53.40
4	34.37	16	54.56
5	37.02	17	55.67
1) 6	39.34	3) 18	56.74
7	41.42	19	57.77
8	43.31	20	58.77
9	45.03	21	59.73
10	46.65	22	60.67
11	48.15	23	61.57
2) 12	49.57	4) 24	62.45

Barrels

Barrels	Cube Root Inch.
25	63. 31
26	64. 14
27	65. 75
28	65. 95
29	66. 52
5) 30	67. 28
31	68. 01
32	68. 74
33	69. 45
34	70. 14
35	70. 82
6) 36	71. 49

Barrels	Cube Root Inch.
37	72. 15
38	72. 79
39	73. 42
40	74. 05
41	74. 66
7) 42	75. 26
43	75. 86
44	76. 44
45	77. 01
46	77. 58
47	78. 14
8) 48	78. 69

Cbue-

Cube-Root-Inches of Tunt.

Tuns	Cube Root Inch.	Tuns	Cube Root Inch.
9	81. 84	25	115. 04
10	84. 76	26	116. 56
11	87. 50	27	118. 03
12	90. 07	28	119. 47
13	92. 51	29	120. 88
14	94. 82	30	122. 25
15	97. 03	31	123. 60
16	99. 14	32	124. 91
17	101. 16	33	126. 20
18	103. 11	34	127. 46
19	104. 95	35	128. 70
20	106. 80	36	129. 91
21	108. 55	37	131. 10
22	110. 24	38	132. 28
23	111. 89	39	133. 40
24	113. 49	40	134. 56

Cube-Root-Inches of Tuns.

Tuns	Cube Root Inch.	Tuns	Cube Root Inch.
41	135. 67	57	151. 42
42	136. 76	58	152. 30
43	137. 84	59	153. 17
44	138. 90	60	154. 03
45	139. 94	61	154. 88
46	140. 97	62	155. 73
47	141. 99	63	156. 56
48	142. 99	64	157. 38
49	143. 97	65	158. 20
50	144. 95	66	159. 01
51	145. 91	67	159. 80
52	146. 86	68	160. 60
53	147. 80	69	161. 38
54	148. 71	70	162. 15
55	149. 63	80	169. 53
56	150. 53	90	176. 31

Cube-Root-Inches of Tuns.

Tuns	Cube Root Inch.	Tuns	Cube Root Inch.
100	182. 62	8000	768. 92
200	230. 09	9000	818. 43
300	263. 39	10000	847. 68
400	289. 90	20000	1068. 06
500	312. 28	30000	1222. 57
600	331. 85	40000	1345. 61
700	349. 35	50000	1449. 52
800	365. 25	60000	1540. 34
900	379. 88	70000	1621. 56
1000	393. 46	80000	1695. 37
2000	495. 73	90000	1763. 25
3000	567. 47	CM.	1826. 28
4000	624. 58		
5000	672. 81		
6000	714. 96		
7000	752. 66		

THE Uſe of this third Table is ſo Obvious to every Mans Capacity, that it needs no Explanation; for if there be occaſion to make any Veſſel in a Cubical Form, of which the Content ought to be a Pint, a Quart, a Gallon, *&c.* This Table gives the Cubick Roots of their Reſpective Dimenſions.

THE FOURTH TABLE.

A TABLE *shewing the true Content of Cubick Feet, (from 1 to 5) in Gallons and Cubick Inches, and (from 5 to 1000) in Barrels, Gallons, and Cubick Inches.*

Cubick Feet	Barrels	Gallons	Cubick Inches
1	0	6	36
2	0	12	72
3	0	18	108
4	0	24	144

Cubick Feet	Barrels	Gallons	Cubick Inches
5	0	30	180
6	1	00	216
7	1	6	252
8	1	13	6
9	1	19	42
10	1	25	78
11	1	31	114
12	2	1	150
13	2	7	186
14	2	13	222
15	2	19	258
16	2	26	12
17	2	32	48
18	3	2	84
19	3	8	120
20	3	14	156
30	5	3	234
40	6	29	30
50	8	18	108
60	10	7	186

Cubick Feet	Barrels	Gallons	Cubick Inches
70	11	32	264
80	13	22	60
90	15	11	138
100	17	00	216
200	34	1	150
300	51	2	84
400	68	3	18
500	85	3	234
600	102	4	168
700	119	5	102
800	136	6	36
900	153	6	252
1000	170	7	186

The ſeveral Uſes of the Fourth TABLE.

Firſt Uſe.

ONE Uſe of this Table is this, *viz.* either by having given the Dimenſions of any Rectangular Veſſel, whoſe ſides are Plain, to find the true Content in Gallons, Barrels, *&c.* or elſe, the Content of any ſuch Veſſel being given with one of its three Dimenſions, to determine the two remaining Dimenſions.

Firſt, Let it be required to know the true Content of a Rectangular

gular Vessel, of which the length is seven, the breadth three, and the height five Feet.

The Answer is this: 7 into 3 into 5, make 105 Cubick Feet: Now by this Table I find that

Barr.

100 Cubick Feet contain 17

Cub. In.

216. and by the same 5 Cubick

Gall. Cub. In.

Feet, contain 30 180 which two Sums being added together

Bar. Gall. Cub. In.

make 17 31 114 which is the Content of the aforesaid Vessel.

Again, The Content of a Vessel being given (*viz.* four Barrels) and the length of that Vessel (six Feet) let it be required

quired to find the Breadth and Depth.

Answer, By this Table I find that six Cubick Feet contain one Barrel, and 216 Cubick Inches. By this I know the Content of a Vessel, whose Length is six Feet, its Breadth one, and its Height one; therefore two such Vessels joined together upon a Plane, or (which is all one) a Vessel six Feet long, two Feet wide, and one Foot deep, contains two Barrels, one Gallon, and one Hundred and fifty Cubick Inches, and by Consequence a Vessel six Feet long, two Feet wide, and two Feet deep, contains four Barrels, three Gallons, and eighteen Cubick Inches, which is something over the given Content, but near enough for common use. And by this Method may any Cistern

Ciſtern be deſigned near enough the Truth, with great Eaſe and Expedition.

But if it be required to perform theſe or the like Operations more exactly, the following Method will guide the Practitioner, ſeveral *Precognita* being firſt laid down.

1. The Original of all long Meaſures is an Inch, whereof twelve make a Standard *Engliſh* Foot, 36 Inches make a Yard; 72 make a Fathom, 198 make a Perch, 7920 make a Furlong, 63360 make a Mile.

2. The Original of all Square Meaſures is a Square Inch, whereof 144 make a Square Foot, 1296 make a Square Yard, 39204 make

make a Square Rod, 6272640 make a Square Acre.

3. Of all Solid Measures the Original is a Cubick Inch, whereof 1728 make a Cubick Foot, 15,552, make a Cubick Yard.

Again 35 \25 make a Pint, 70 \5 make a Quart, 282 make a Gallon, 10,152 make a Barrel, or Thirty six Gallons; 60,912 make a Tun or Six Barrels.

4. Any one Number being Multiplied either by it self, or any other Number, and that Product Multiplied by any third Number make a Solid, or the Content of a Rectangular Ciſtern, whoſe ſides are plain.

Theſe *Precognita* being laid down,

down the Operations will be as follow :

For Example, The Content of a Ciſtern being given, *viz.* Four Barrels, and the length of that Ciſtern ſix Feet : Let it be required to find out two Numbers, which being Multiplied one into another, and that Product into the given Length, make a Content equal to Four Barrels.

Having firſt Reduced the given Terms to their leaſt Denominations, the *General Rule* is this :

The Content of any Rectangular Veſſel being given together, with either the length, or breadth, or Depth of that Ciſtern ; Divide the given Content by the given Dimenſion, and the Quotient by any Number

ber leſs than it ſelf: The laſt Diviſor and Quotient are the two Terms ſought.

Thus having reduced the Four Barrels to 40,608 Inches, and the given 6 Feet to to 72 Inches, I divide the ſaid 40,608 by the ſaid 72. And again I divide the Quotient 564 Inches by any Number leſs than it ſelf, ſuppoſe 40, the laſt Diviſor 40, and its Quotient 14 1 are the two ſides required. And after this Method may infinite Anſwers be given to this Queſtion; ſo that the Operator in the ſecond Diviſion may from the given length chuſe either what Depth or Breadth he pleaſes, or from a given given Depth may chuſe what Length

Length or Breadth he pleases.

The Second Use of the Fourth TABLE.

To Explain this Use it is necessary to premise this following *Theorem*:

Like Solids are in proportion one to another, as the Cubes of their Homologous sides.

Upon which *Theorem* depends this *Problem*:

Having the Content of a Cistern, together with the Ratio of the Length, Breadth and Height given to find the sides.

I. *Ex-*

1. *Example*, Let it be demanded to frame a Ciſtern containing 1000 Cubick Feet, and the Ratio of the ſides or three Dimenſions, let be one two and four.

Firſt, I imagine, or frame in my mind, a Ciſtern, whoſe

Length——— 4
Breadth—— 2
Height—— 1

The Content of it is 4x2x1=(8)

Therefore I ſay,

1. As the Content 8. is to the Content 1000, ſo is the Cube of the ſide 4. *viz.* the Cube 64. to the Cube 8000, whoſe Cube-Root is=20.

2. As the ſaid 8. to the ſaid 1000. ſo is the Cube of the ſide 2. *viz.* the Cube 8. to the Cube 1000. whoſe Cube Root is = 10.

3. As the ſaid 8 to the ſaid 1000. ſo is the Cube of the ſide 1. *viz.* Cube 1. to the Cube 125. whoſe Cube Root is = 5.

So then of the Ciſtern demanded to be framed, the

Length ——— 20
Breadth —— 10
Height —— 5.

For 20x10x5 = 1000; and

1. As 1 to 2, ſo 5 to 10.
2. As 2 to 4, ſo 10 to 20.
3. As 1 to 4, ſo 5 to 20.

II. Ex-

II. *Example*, Let a Ciſtern be demanded, containing 600 Cubick Feet, and the Ratio of the ſides, as 3, 4, 5.

Firſt, I frame in my mind a Ciſtern of 3 4 5, 3+4+5=60. wherefore.

As to the Content 60. to the Content 600. ſo is the Cube of the ſide 3. *viz.* the Cube 27 to the Cube 270. whoſe Cube Root is =6. 463.

2. As the ſaid 60 to the ſaid 600. ſo is the Cube of the ſide 4. *viz.* the Cube 64, to the Cube 640, whoſe Cube Root is=8. 617.

3. As the ſaid 60 to the ſaid 600. ſo is the Cube of the ſide 5. *viz.* the Cube 125. to the Cube

Cube 1250, whose Cube Root is=10. 7720.

So then

	Content	Length	Breadth	height
Of the given Cistern	160	5	4	3.
Of the Cistern demanded	600	10.7720	8.6176	6

4632

For

6.4632 into 8.6176 into 10.7720 is=599. 978.

And

1. As 3 to 4, so is 6.4632 to 8.6176
2. As 4 to 5, so is 8.6176. to 10.7720
3. As 3 to 5, so is 6.4362 to 10.7720.

This *Problem* being clearly Answered by the two foregoing Examples;

Examples; in the first of which the Length, Breadth and Depth of the Ciſtern, that is required to be deſigned, are 20, 10 and 5; and its Content 1000 Cubick Feet; and in the ſecond the Length, Breadth and Depth of the Ciſtern that is required to be deſigned are 10,7720, 8.6176 and 6.4632. and its Content 600 Cubcik Feet. The next thing to be done is to Convert their Contents into Gallons, Barrels, *&c.* which is to be done with much eaſe by this Fourth Table: For by that Table 1000 Cubick Feet (which is the Content of the firſt Ciſtern required to be deſigned) contain

Bar.	*Gall.*	*Cub. Inch.*
170	7	186.

And

And in the second Example the Content of the Cistern required to be designed, being 600 Cubick Feet; I find by the said Table, that 600 Cubick Feet contain

Bar.	*Gall.*	*Cub. Inch.*
102	4	168

The Third Use.

The third Use of this Table relates to Cylindrical Elliptical Vessels; for the better Explanation of which there are again several *Precognita* to be premised.

I. Diam

I. *Diam of any Circle*	*Peripherie*
1 = =	3. 14159265
2 = =	6. 28318530
3 = =	9. 42477795
4 = =	12. 56637060
5 = =	15. 70796325
6 = =	18. 84955590
7 = =	21. 99118455
8 = =	25. 13274120
9. = =	28. 27433385

II. Diam

I. *Diam of any Circle*		*Square Root of the Area*
1	= =	0. 88622692
2	= =	1. 77245385.
3	= =	2. 65868077
4	= =	3. 54490770
5	= =	4. 43114362
6	= =	5. 31736155
7	= =	6. 20358847
9	= =	7. 97604231

If the Diam be (1) the Area is 0. 785398163.

4. Square any given Diameter, and then Multiply that Square by 0. 7853, &c. and the

the last Produce is the *Area* of the Circle.

5. The Length of an *Ellipsis* drawn into the Breadth, and that Product Multiplied by 0. 7853981, *&c.* gives the *Area* of an *Ellipsis*.

6. Circles in proportion to one another, as the Squares of their Diameters.

First Problem.

The Diameter of any Cilindrical Vessel being given, together with its Height, to find the true Content thereof in Gallons, Barrels, *&c.*

For Example, Suppose in a Noblemans or Gentlemans Garden there

there be found a Baſon, whoſe Diameter is 45 Feet, and its Depth 4 Feet, and it be required to know the true Content thereof in Gallons, Barrels and Tuns.——

Anſwer. By the Fourth *Præcognitum*, I ſquare the given Diameter 45. and that Square I Multiply by the Fraction 0.7853, *&c.* and the Product 1590. 232 is the Area of the Circle, which Multiply by 4, the Height of the Cylindrical Veſſel, and the Product, *viz.* 6360. 9--- Cubick Feet, is the Content of the Baſon.

This being done, the next thing is to convert the ſaid Cubick Feet into Gallons, Barrels and Tuns; which, by the help of the Fourth Table, is eaſily done.

For by the said Table, 1000 Cubick Feet is equal to

Barr.	Gall.	Cub. In.
170	7	186,

which being Multiplied by Six gives

Barr.	Gall.	Cub. In.
1020,	42	1116,

which is being reduced to its right Denomination,

Barr.	Gall.	Cub. In.
1021	9	270

the Content of 6000 Cubick Inches.

Again. 300 Cubick Feet is equal to

B.	G.	C. In.
51	2	84,

this being added to the foregoing Sum, *viz.*

B.	G.	C. In.
1021	9	270
51	2	84
makes 1072	11	354

the Content of 6300 Cubick Feet.

Lastly,

Lastly, 60 Cubick Feet contain

B.	G.	C.In.
10	7	186

which being added to the Content of 6300 Cubick Feet, *viz.*

B.	G.	C.In.
1072	11	354
10	7	186

makes 1082 — 18 — 540

which Reduced to its right Denomination is

B.	G.	C.In.
1082	19	258

the Content of the Bason which was required.

Second Problem.

The long and short Diameters of an Elliptical Vessel being given, together with the Height,

to find the true Content thereof in Gallons, Barrels, &c.

Suppose in a Gentlemans or Noblemans Garden there be an Elliptical Bason, whose Length is 45 Feet, whose Breadth is 35 Feet, and whose Depth is 4 Feet; and it be required to know the true Content thereof in Gallons, Barrels and Tuns.

Answer. By the Fifth *Precognitum*, I Multiply 45 the Length into 35, the Breadth of the Bason; the Product which is 1575, I Multiply by the Fraction 0.7853, and the Product of these two Numbers Multiplied, will be 1236. 847. which I then Multiply by 4 the Depth, and thence arises 4947.3... Cubick Feet which is the Content of the Bason. Now I, as before, Convert the said

Cubick Feet into Gallons, Barrels and Tuns, by the help of the Fourth Table. Thus,

1000 Cubick Feet is there equal to

Barr.	Gall.	Cub. In.
17c	7	186

which being Multiplied by 4 gives

Barr.	Gall.	Cub. In.
680	28	744

which (being reduced to its right Denomination) is

Barr.	Gall.	Cub. In.
680	30	180

Again, 900 Cubick Feet is equal

Barr.	Gall.	Cub. In.
to 153	6	252

this being added to the foregoing Sum, *viz.*

Barr.	Gall.	Cub. In.
680	30	180
153	6	252
makes 833	36	432

which is (being reduced)

Barr.	Gall.	Cub.In.
833	37	150

Lastly, 40 Cubick Feet contain

Barr.	Gall.	Cub.In.
6	29	30

And 7 Cubick Feet contain

Barr.	Gall.	Cub.In.
1	6	252

therefore 47 Cubick Feet contain

Barr.	Gall.	Cub.In.
7	35	282

which being added to the Content of 4900 Cubick Feet, *viz.*

Barr.	Gall.	Cub.In.
833	37	150
7	35	282
makes 840	73	150

which (being reduced to its right Denomination) is

Barr.	Gall.	Cub.In.
842	1	150

the Content of the Bason, in Barrels,

rels, Gallons and Cubick Inches, which was required.

But forasmuch as in the Practical part of *Hydrostaticks*, and the designing of Engines to raise Water to great Heights, by the means of Forcers; it will be often requisite to know the Contents and the Weight of less Cylinders, that is to say, whose Diameters are 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 Inches, and the Length Indefinite (suppose from 1 to 100, or more). And because such Calculations are very tedious, I have here inserted the following Table.

THE FIFTH

TABLE

Giving the true Content in Cubick Inches of Cylinders of different Diameters, from 1 *to* 12 *Inclusive, and each of these Cylinders of a Foot or Twelve Inches in Height.*

Diam of Baſes	*Solid Content in Cubick Inches.*
1	9|42477|961
2	37|69911|843
3	84|82300|1647

4			150 79644736
5			235 61944900
6			339 29200656
7			461 81412004
8			603 18578044
9			763 40701476
10			942 47779600
11			1140 39813316
12			1357 16802624

As for the weight of Water, it is not to be determined absolutely, becauſe almoſt all Wells, Springs and Rivers, are of a different weight, and therefore my advice is to all Engineers and Practitioners, to find out the ex-

act weight of a Cubick Foot of that particular Water, which they have occaſion to make uſe of; by which means they will eaſily diſcover the weight of any Cylinder of Water with theſe following Cautions.

Firſt Caution. When an Engineer deſires to force up Water 50, or 100 Feet in Perpendicular Height, and deſigns to do this by a Forcer of 4, 5, or 6 Inches Diameter; but intends the Water ſhall be carried up the ſaid 50, or 100 Feet in Perpendicular Height, through a Pipe of of 1 Inch and ½, 1 Inch and ¼, or 2 Inches and ⅛ Diameter, the Water ſtanding in any ſuch perpendicular Pipe, is equivalent in weight to a Pipe of the ſame Perpendicular Height, whoſe Diameter is 4, 5, or 6 Inches, *viz.*

viz. the Diameter of the ſaid Forcer; and indeed the leſs one of thoſe Pipes is, the greater is the weight againſt the Forcer to raiſe up the Water in the ſame Moment or Interval of Time; that is to ſay, there is required more Weight to be laid upon that Forcer, to raiſe the Water through a Pipe of one Inch Diameter, than through a Pipe of four Inches Diameter. And whatſoever is here ſaid of the weight of Water againſt a Forcer, in a Forcing Engine, is alſo true in Suction, by a Drawing Pump.

For Example. A Pump whoſe Barrel or Pipe of Suction is four Inches Diameter; and the Pipe wherin reaches from the Barrel to the Water, through which it is drawn up but two Inches Diameter, requires more force or ſtrength,

ſtrength, than if it were drawn up through a Pipe of four Inches Diameter. For want of the Knowledge of this, many ignonorant Plummers and Pump-makers, covet to draw their Water through leſs Pipes, which makes the Work more difficult: And though this ſeems to be a Paradox, yet 'tis a real truth; and the want of the right underſtanding thereof has occaſioned very many great Miſtakes by ignorant Practitioners.

Second Caution. The true weight of Water in all Pipes, is to be determined by the Perpendicular Height of thoſe Pipes.

For Example. The weight of Water in Perpendicular Pipes of three Feet (in Height) and three Inches Diameter, is equal to the weight

weight of Water contained in a Pipe of any Length whatever (be it a Rod, a Furlong, or more) which rises not more than three Feet above the Horizontal Line; which seems likewise to be a Mystery, but is a real truth, as it lyes in the Pipes; although if it be taken out and laid in a Ballance, it will weigh one Hundred times as much or more, than the Water in the said Perpendicular Pipe.

I must confess, that the Author had very small Encouragement to help our Engineers in things of this Nature, many of them having dealt very disingenuously with him; when he had, by near Forty Years Study and Practise, and the Expence of many a thousand Pounds, produced

produced new and better ways of raising Water, than for ought I know, were ever known to former Ages, *viz.* by the means of

1. A *Forcer* moving up and down in a *Chamber* of Water, through a small *Collar* or *Neck* of *Leather* fastned in a *Groove*.

2. The *Circular Motion* of a *Crank*, reduced to a *Perpendicular*.

3. The *Unequal Motion* of a *Crank* exchanged for an *Elliptical Equal Motion*.

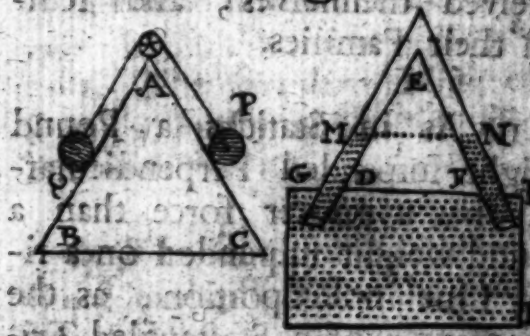
Divers Persons have borrowed, some one part, some another, and making some small Alterations, call it their own Invention. This I am willing to

to let pass it, and after all, to give them the following Items, to prevent their attempting Perpetual Motions, which most of them are apt to do by their Ignorance in Hydrostaticks; and not a few Gentlemen, in all Ages, have, by such vain imaginations of deceiving Nature, deceived themselves, and Ruined their Families.

IV. As in Staticks a Pound weight suspended Perpendicularly, has a greater force than a Pound weight suspended on a rising Line in Proportion, as the Hypotenuse of a Rectangled Triangle, is longer than its Perpendicular; so in Hydrostaticks, if the two ends of a Syphon turned angular-wise, and a part of it filled with Water, or any other Liquor, be immerged

ged in a Veſſel of the ſame Liquor; that part which hangs Perpendicularly, ſhall be heavier than that which declines in proportion, as one ſide of that Syphon is longer than the other oppoſite ſide.

1. Fig.

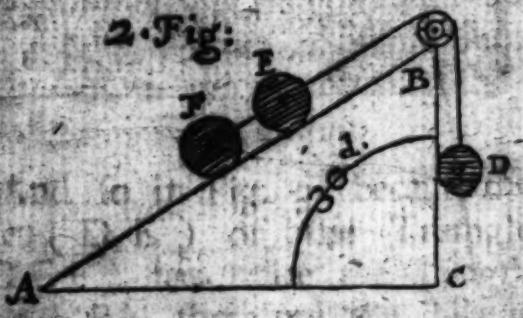


For Example. Let the two Triangles in *Fig.* 1. be Iſoſceles, and the two ſides of the Triangle A B C (*viz.* A C and A B) equal. And ſo likewiſe the two ſides of the Triangle D E F

(*viz.*

(*viz.* D E and E F) equal. In this case a Pound weight (P) and another (Q) are equally Ponderous; and so is the Water contained in the Syphon (F N) from the Superfices (G R) to (N) of an equal weight with the Water in the Syphon (D M) between the Superfices of the Water (G R) and (M).

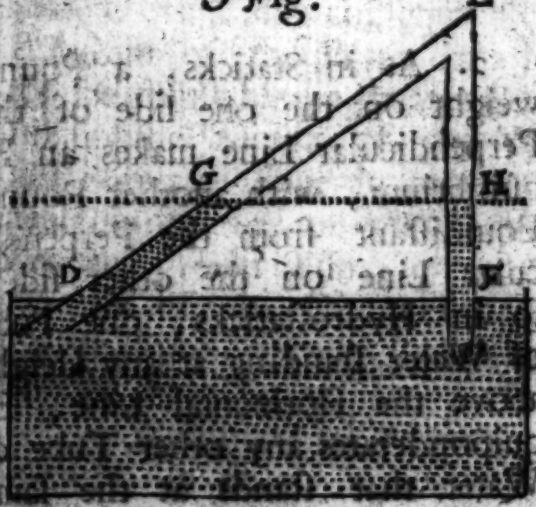
2. Fig:



But now in Fig. 2. because the side (A B) of the Triangle (A B C) has double the length of (B C) therefore a Pound

Pound weight (D) ſuſpended Perpendicularly from (B) is Equiponderant to two Pounds (E and F) on the ſide (A B) according to the Doctrine of Statiks. And therefore an Horſe drawing a weight of four Hundred Pound, upon an Aſcent of thirty Deg. heaves at two Hundred Pound, which is one half, and the Ground bears the reſt.

3 Fig.



And ſo in Fig. 3. becauſe the ide (D E) of the Triangle D E F) has twice the Length f (E F) therefore the Water H F) which hangs Perpendi-ularly, is equal in weight to he Water (D G) which has wice its Quantity and Length, according

according to the Doctrine of Hydroſtaticks.

2. As in Staticks, a Pound weight on the one ſide of the Perpendicular Line makes an Equilibrium, with another Pound Equidiſtant from the Perpendicular Line on the other ſide ſo in Hydroſtaticks, one Tube of Water ſtanding at any Height above the Horizontal Line, Equiponderates any other Tube of Water that ſtands at the ſame Height, and is of the ſame Diameter.

3. As in Staticks if a leſs weight raiſe a greater, it muſt be proportionably at a greater diſtance from the Perpendicular Line, and have a greater Motion. So in Hydroſtaticks a leſs Tube of Water raiſe

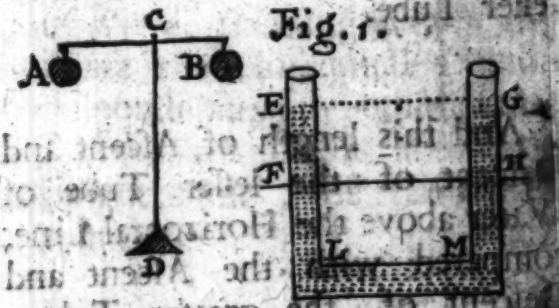
greate

greater Tube, it must be proportionably of a greater Length above the Horizontal Line than the other; and consequently the Descent of the Water in a lesser Tube, must have a greater Length than the Ascent of the Water in a greater Tube in proportion, as the Square of the Diameter of the greater Tube, exceeds the Square of the Diameter of the lesser Tube.

And this length of Ascent and Descent of the lesser Tube of Water above the Horizontal Line, compared with the Ascent and Descent of the greater Tube, together with the proportion that the Square of the Diameter of the lesser Tube, bears to the Square of the Diameter of the greater

greater Tube, answers exactly to the force and Motion of a Leaver, or rather of a lesser weight placed on a Ballance at a greater distance from the Perpendicular to Counterpoise or raise a greater weight placed on the other side at a lesser distance according to the Doctrine of Staticks.

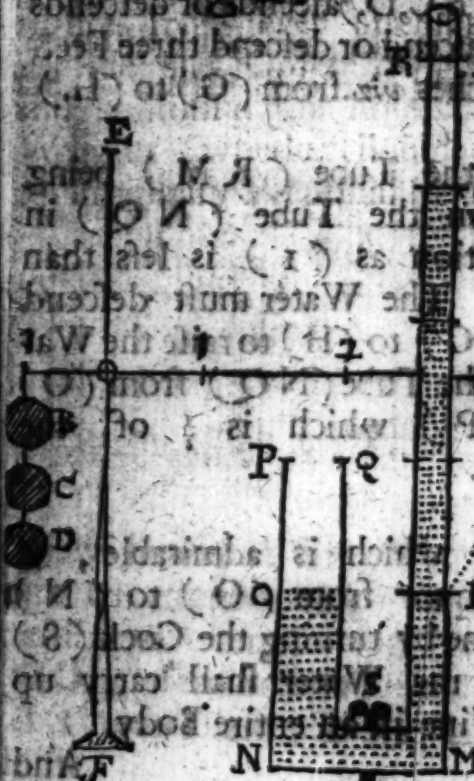
Fig. 1.



As in Fig. 1. A pound weight (A) is equiponderant to another (B) becaufe equidistant from the Perpendicular (CD) So that part of the Tube (EL) whose

whose Height above the Horizontal Line (FE) is of an equal Height with that part of the Tube (G M) which is of an equal Height above (FH) *viz.* (GH.)

Fig. 2.



In

In Fig. 2. as a pound weight A equiponderating three Pound (B, C, D,) must have thrice the Distance from the Perpendicular (E F) and for every Foot or Inch (B, C, D,) ascends or descends A must ascend or descend three Feet, or 3 Inches, *viz.* from (G) to (H.)

So the Tube (R M) being less than the Tube (N Q) in Proportion as (1) is less than three. The Water must descend from (G) to (H) to raise the Water in the Tube (N Q) from (O) to (P) which is $\frac{1}{3}$ of the Height.

And which is admirable, if the Liquor from (O) to (N) be Wine by turning the Cock (S) gently the Water shall carry up the Wine in an entire Body.

And

And this is a pretty Experiment in Hydroſtaticks; and theſe Cautionary Reflections will, I preſume, if throughly underſtood, diſcourage young Practitioners from ever attempting to deceive the Order of Nature, and confound the Equilibrium of Weights (whether liquid or dry) by imaginary Perpetual Motions.

D THE

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D THE

THE LAST TABLE.

A most Excellent TABLE *of* POLIGONES *from* 3 *to* 80, *Calculated to a Radus of* 10,000,000, *by that incomparable Master of Numbers,* LUDOLPHUS A CULEN, *Published* Anno Dom. 1619.

Pol.		Pol.	
3	17, 320, 508	7	8, 677, 674
4	14, 242, 135	8	7, 653, 668
5	11, 755, 705	9	6, 840, 402
6	10, 000, 000	10	6, 180, 339

Pol.

Pol.	
11	5, 634, 651
12	5, 176, 380
13	4, 786, 313
14	4, 450, 418
15	4, 158, 233
16	3, 901, 806
17	3, 674, 990
18	3, 472, 993
19	3, 291, 891
20	3, 128, 689
21	2, 980, 845
22	2, 846, 296
23	2, 723, 332
24	2, 610, 523
25	2, 506, 660
26	2, 410, 733
27	2, 321, 858
28	2, 239, 289
29	2, 162, 380
30	2, 090, 569

Pol.	
31	2, 023, 366
32	1, 960, 342
33	1, 901, 120
34	1, 845, 362
35	1, 792, 786
36	1, 743, 114
37	1, 696, 118
38	1, 651, 586
39	1, 609, 331
40	1, 561, 181
41	1, 530, 985
42	1, 494, 601
43	1, 459, 906
44	1, 426, 783
45	1, 395, 129
46	1, 364, 848
47	1, 335, 852
48	1, 308, 062
49	1, 281, 404
50	1, 255, 810

Pol.	
51	1, 231, 218
52	1, 207, 569
53	1, 184, 812
54	1, 162, 896
55	1, 141, 776
56	1, 121, 408
57	1, 101, 755
58	1, 082, 778
59	1, 074, 453
60	1, 046, 719
61	1, 029, 575
62	1, 012, 983
63	0, 996, 912
64	0, 981, 353
65	0, 966, 275
66	0, 951, 638

Pol.	
67	0, 937, 445
68	0, 923, 669
69	0, 910, 291
70	0, 897, 296
71	0, 884, 666
72	0, 872, 387
73	0, 860, 444
74	0, 848, 824
75	0, 837, 513
76	0, 826, 499
77	0, 815, 771
78	0, 805, 318
79	0, 795, 130
80	0, 785, 196

The Use of the TABLE *of* Polygones.

SUppose you had a Wheel, in which you intend there should be Forty Coggs or Teeth, standing at equal Distances, and the Diameter of this Wheel be Thirty Three. By this Table you must proceed thus; First having taken half 33. which is 16.5 for the Radius of your Circle, look out the side of the Polygon of 40, standing over against that Number in the Table, which is 1,561.

Then say,

As 10,000. 1,561. so 16. 5. 2,575. this taken off a Line of equal parts, by which you measure your *Radius*, will rightly

divide your Circle; and each of theſe Points of Diviſion ſo found, will be Centers for your Teeth or Coggs.

There are other Operations relating to the Diviſion of Wheels, or Circles, which may be nicely performed by the Aſſiſtance of this Table; but the Nature of it being underſtood, 'tis eaſie to apply it to thoſe other Uſes.

Note, To ſhorten the Work, I thought it convenient to take a leſſer Radius, as 10.000. and 1.561, which ſtands over againſt 40 in the Table, will conſiſt of the firſt Figure an Integer, and the reſt Decimals; and as you take a greater

ter or a leſs *Radius*, you muſt make uſe of more or fewer Figures, throughout the whole Table.

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